COLONY FOUNDING BY QUEENS OF *SOLENOPSIS MOLESTA* (HYMENOPTERA: FORMICIDAE)[1]

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ABSTRACT: Founding queens of *Solenopsis molesta* were collected, isolated, and studied for 100 days. Although the presumed method of colony foundation is haplometrotic, only two queens established colonies with workers during this time. Minimum developmental time was determined to be 49 days from egg to worker at 23 degrees C. Queens began to lay eggs 3 days after mating. Less than 50% of the queens survived the first 100 days. The biology of these founding queens is reviewed and briefly compared with the distantly related *Solenopsis invicta.*

Although the preferred habitat of *Solenopsis molesta* is open fields and meadows (Wilson and Hunt, 1966), this species readily accepts suburban lawns (DuBois and La Berge, 1988). Most colonies have a single queen. In spite of its abundance, many aspects of the biology of this species, including details of nest establishment, are unknown.

Ant colonies may have three stages of growth; a founding stage, an exponential growth stage, and a reproductive stage (Oster and Wilson, 1978). Previous studies of *S. molesta* have concentrated upon the latter two stages of colony growth. McColloch and Hayes (1916) studied the economic importance and life history of *S. molesta.* Development was summarized as follows: egg stage 16-28 days, larvae 21 days, semi-pupa [last instar larvae] 2-11 days, pupae 13-27 days; minimum development time (egg to adult worker), 52 days. Overwintering larvae had significantly longer development times. Their findings were based upon mature colonies collected in the field and observed in the lab. They noted that "queens unattended by workers will rear and care for their young." (McColloch and Hayes, 1916: 31). They inferred newly fertilized queens are able to establish colonies without worker assistance.

Hayes (1920) confirmed that minimum worker development time from egg to adult, in an established colony, is 52 days. He provided detailed descriptions of worker, queen, male, and immature stages and noted that the number of fertile queens ranged from one per colony to one colony containing 26 dealate queens. No queens in laboratory colonies lived through an entire summer nor survived over winter.

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However, he noted queens were discovered outdoors in May, indicating they could survive the winter under natural conditions.

Macnamara (1945) briefly reported on a nuptial flight of this species. He encountered "two or three small clouds of insects" which were identified as *Solenopsis molesta*. He described the swarms further and noted that some queens were carrying workers. He estimated the swarms might contain tens of thousands of queens with every third queen carrying a worker.

Wilson and Hunt (1966) studied habitat selection by *Solenopsis molesta* queens during and after their nuptial flight. Queens actively selected a preferred macrohabitat ("mowed fields"), but relocated queens would accept alternative habitats. Once queens landed, they exhibited microhabitat selection by locating, a "sheltering leaf, grass stem, or clump of earth." (Wilson and Hunt, 1966: 487).

In July 1991, founding queens of *Solenopsis molesta* were collected and placed together in a suitable nesting chamber. Mortality among queens was high; all but one was dead when the first workers emerged. The resulting colony never achieved significant size, and the remaining queen died within two months of the first worker emergence (M. DuBois, pers. obs.). Due to the limited published studies on colony founding of this species and the above observations, it was decided to determine if reproductives of this species could establish colonies haplometrotically.

MATERIALS AND METHODS

Queens were collected at dusk (8:30-9:30 pm) on July 26, 1992 [ILLINOIS: Tazewell Co., Washington, 116 Burton Street]. Presumably, they had recently descended from their mating flight, as no nearby colonies were releasing reproductives and there were no workers nearby. Queens were walking on a brick sidewalk and a concrete driveway, and were presumably engaged in the microhabitat selection described by Wilson and Hunt (1966). Most queens had shed their wings; a few were starting to tunnel into the sand between the bricks in the sidewalk. A total of 62 queens were collected from the surface. No workers were found in association with the queens. An area slightly in excess of 30 m^2 was searched. It was apparent that the abundance of queens extended beyond the immediate range; however, the full extent of the area could not be determined (due to lawns and fences in this disturbed, urban setting). Nearby areas searched in a cursory fashion revealed a similar concentration (2 queens per m^2). Subsequent searching on the following night (July 27) revealed 2 additional isolated queens. No additional queens were located on following nights (July 28 on).

Ants were observed (July 26) when the air was dry with no wind. It had rained heavily the previous day (over 3 cm) with sporadic rainstorms for several days preceding as well. The soil was visibly moist. Air temperature was 19.5 degrees C, relative humidity was 61% and barometric pressure was 737 mm Hg (constant).

Individual queens were isolated in test tubes (1 cm diameter) partly filled with water (separated from the queen by a cotton plug). Each tube was capped with another cotton plug. Queens were observed daily (under red light) and verified they were alive by noting motion of legs or antennae. Records were taken noting ambient air temperature, time, presence and type of brood (including workers). Queens were observed for 100 days. By that time (early November), the outside environment was too cold for ants to function. Queens were then refrigerated for further study the following spring. They were stored between 5 and 6 degrees C for 164 days at 100° humidity.

Voucher specimens (queens) have been deposited in the authors' personal collection and the Illinois Natural History Survey.

RESULTS

Only 26 of the 62 queens survived two months in the lab (table 2). Initial mortality may have been due to handling during capture; however, subsequent deaths occurred at a steady rate through the remainder of the study (on average 1 queen died every 3 days) (figure 1). Of the 62 queens observed, 5 (8%) established colonies with workers. Of these 5 colonies, only 2 (3%) survived with workers until the end of 100 days. Prime causes of death appeared to be related to various molds which became established in the damp chambers.

All queens began laying eggs within 10 days. Egg laying then decreased through most of the remaining days (figure 1). Those queens which established successful colonies were ones which were able to rear their offspring from these initial eggs. Queens which lost their initial investment in eggs due to mold or cannibalism were only able to rear larvae within the first 100 days. Only 8 queens successfully reared their offspring to the pupal stage (figure 1). By the end of the 100 days, there were no pupae. Similarly, only 5 queens were able to produce workers (figure 1).

Minimum developmental times were observed for all stages. Although some individuals took longer at various stages, the time indicated (table 1) represents the minimum amount of time for a founding queen to establish a colony with at least one worker present. The first worker actually appeared on day 53 (figure 1). Although minimum

developmental time was 49 days, queens did not begin laying eggs until 3 days after mating.

Colony composition was reviewed every 20 days (table 2). After 20 days, August 14, 1992, all queens had both eggs and larvae. Forty days after capture (September 3) some pupae were present in a few nests; however a number of queens (18) had no developing brood at all. Sixty days after capture (September 23) four queens had mature workers. By October 3 (80 days after capture) the number of queens lacking brood had increased to 21. This remained constant through 100 days.

Queens were removed for further study on April 10, 1993 (164 days after being refrigerated). Of the 26 queens refrigerated, 5 died demonstrating that queens can survive low temperatures for extended periods of time.

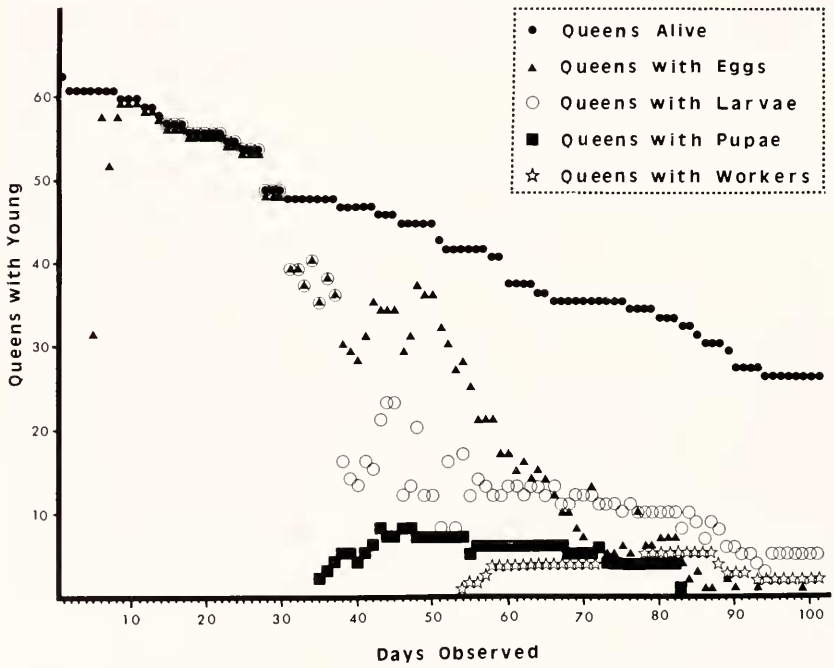

Figure 1. Development of colonies from founding queens (number of queens with young) of *Solenopsis molesta*. Once queens died, unattended offspring died rapidly. The first 101 days of growth are shown. For further discussion, see text.

DISCUSSION

The ant tribe Solenopsidini contains two dominant genera: *Monomorium* and *Solenopsis*. Over 300 species of *Monomorium* have been described (DuBois, 1986; Bolton, 1987). Of these only *Monomorium pharaonis* has been comprehensively studied (for example, Peacock and Baxter, 1950). *Solenopsis* contains a comparable number of species; only the biology of the "fire ant," *Solenopsis invicta* has been studied in depth (for an early example, Wilson 1966). Thus, only 2 species out of over 500 have been extensively studied.

It is reasonable to expect that young colonies of *S. molesta* will attempt to maximize the number of workers. Ants foraging for food are most susceptible to predation Therefore, most queens found their colonies in isolation (histolyzing their flight muscles for nourishment and production of trophic eggs to feed their offspring). By rapidly generating workers a colony increases its chance for success (Oster and Wilson, 1978).

Assuming that queens dispersing after their mating flight cover a reasonably large area in a relatively uniform manner (as was observed), initial concentrations of queens appear relatively high (about 2 per m^2 in the area searched). Extrapolated to a hectare, this would yield about 20,500 queens per hectare. Macnamara (1945) observed tens of thousands of queens per mating swarm. Since queens should live at least three years (based upon observations of laboratory colonies), this means a potential concentration of over 6.1 colonies per m^2 within three years. It appears that mating flights populate the same area with founding queens every year (pers. obs.). Previous field observations yielded observed densities of less than 1 colony per m^2. Mortality must play a significant role in the actual number of colonies.

It appears that colony foundation in *Solenopsis molesta* is haplometrotic. However, some ants have diverse methods of colony foundation. For example, the Australian meat ant, *Iridomyrmex purpureus,* is capable of founding colonies haplometrotically, pleometrotically, or by colony budding (Hölldobler and Carlin, 1985). Furthermore, Tschinkel and Howard (1983) indicated that newly mated queens of *Solenopsis invicta* are able to establish colonies either haplometrotically or by cooperating with other queens (pleometrotically). No workers were found accompanying queens in this study in contrast with Macnamara's (1945) findings. Additionally, MacKay *et al.* (1991) reported that survivorship among queens in monogynous colonies of *S. invicta* was higher than for queens in polygynous colonies. Additional studies of *S. molesta* should compare queens isolated in chambers and grouped

together. Although clusters of dealate queens of *S.invicta* are observed in the field, no such clusters have been noted for *S. molesta.*

Minimum development times in this study agree with those reported by McColloch and Hayes (1916) and Hayes (1920). Development of offspring is slower in *Solenopsis molesta* than the distantly related (and larger) *S.invicta.* Kahn *et al.* (1967) reported that queens of *S.invicta* produced workers in 22-28 days. Markin *et al.* (1972) determined the optimum temperature for development was 29.5 degrees C with workers produced in 22 days. Optimum developmental temperature for *S. molesta* is unknown. Average temperature in the present study was 23 degrees C. Data from Markin *et al.* (1972) for average temperature of 24 degrees C yielded similar developmental times for *S.invicta.*

Queen mortality in the laboratory was high and only a small percentage (3%) of newly mated queens of *Solenopsis molesta* were able to establish colonies after 100 days. This contrasts with the distantly related *Solenopsis invicta.* Stringer *et al.* (1976) reported that 74% (111 out of 150 queens) had produced worker ants within 8 weeks. Given the relatively small size of *Solenopsis molesta* queens, they may be more susceptible to dessication. O'Neal and Markin (1973) reported that eggs are rapidly attacked by fungus without almost continual care. Additionally, Markin *et al.* (1972) reported that developing larvae of *Solenopsis invicta* are fed trophic eggs. This was also observed in *Solenopsis molesta.* There may be a limit to the number of trophic eggs which each queen can produce by histolyzing her flight muscles. This might prevent queens from having more than one chance at establishing their colonies.

It is hoped this paper stimulates further biological investigations on other species of the ant tribe Solenopsidini. It has been demonstrated that *S. molesta* can establish colonies in the lab (haplometrotically) and that queens can be kept under refrigeration for extended periods of time.

Table 1. Minimum development times for each life stage of *Solenopsis molesta* workers. For further discussion, see text.

Table 1.

Life Stage	Minimum Development Time (Days)
Egg	11
Larva	19
Pupa	19
TOTAL DAYS	49

Table 2. Development details within each colony at selected dates. Dates are shown every 20 days from date founding queens were collected. For further discussion, see text.

Table 2.

Date (Days after Capture)	Queens Alive	Queens with Eggs	Queens with Larvae	Queens with Pupae	Queens with Workers	Queens with No Brood
14Aug-92 (20 days)	55	55	55	0	0	0
03-Sep-92 (40 days)	46	28	13	4	0	18
23-Sep-92 (60 days)	37	17	13	6	4	20
13-Oct-92 (80 days)	33	7	10	4	5	21
02-Nov-92 (100 days)	26	0	5	0	2	21

ACKNOWLEDGMENTS

We wish to thank Jeri DuBois for tolerating numerous ant colonies in the house. Without her support, this work would not have been possible. The following individuals contributed to the quality of the manuscript with their reviews: Wallace LaBerge and Larry Page (Illinois Natural History Survey), Jon Gelhaus (Academy of Natural Sciences), Mark Deyrup (Archbold Biological Station), and Lloyd Davis, Jr. (U.S.D A). We accept responsibility for any errors or omissions which have remained.

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BOOK RECEIVED AND BRIEFLY NOTED

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Now available for the first time in paperback, *The Dance Language and Orientation of Bees*, originally published in 1967, described in non-technical language what Professor Karl von Frisch discovered in a lifetime of studies about honeybees — their methods of orientation, their sensory faculties, and their remarkable ability to communicate with one another. Thomas Seeley's new foreword traces the revolutionary effects of von Frisch's work, not just for the study of bees, but for all subsequent research in animal behavior. A great opportunity at a bargain price.

ERRATA

In the paper by W.P. McCafferty on "Distributional and classificatory supplement to the burrowing mayflies of the United States" in the Vol. 105, No. 1, January & February, 1994 issue of ENT. NEWS, two last minute printer's errors developed on page 11.

First, the last line on page 10 was repeated as the top line on page 11. This line should be deleted on the top of page 11.

Second, the last line of text on page 11, above Table 1, was dropped out. This line, which needs to be reinserted, should have read:

vae). PENNSYLVANIA, L.M. Bartlett (larvae), no other data. VIR-

ENT. NEWS regrets these errors. Complete new reprints have been furnished to the author and are available from him.